The Nornet Edge Testbed for Mobile Broadband Measurements

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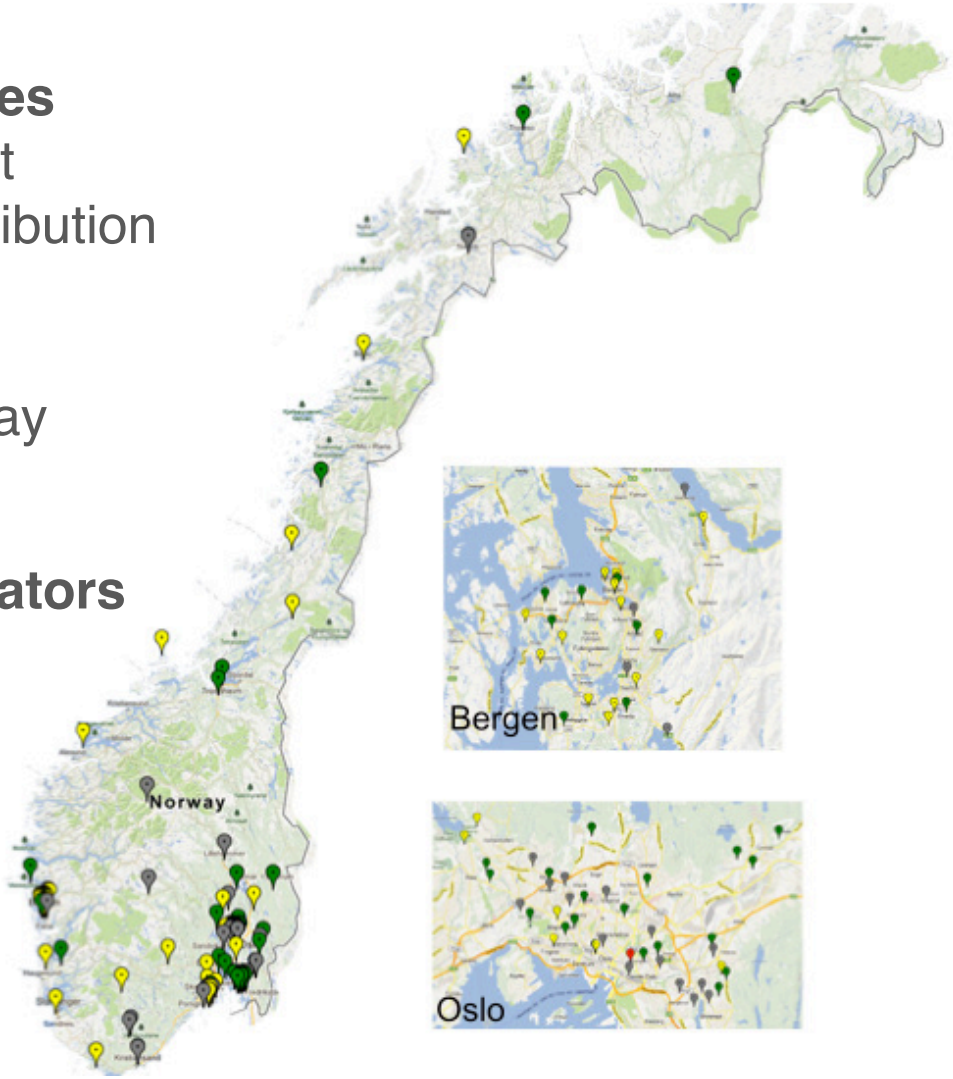
Nornet Edge testbed

400 dedicated measurement nodes
- specially developed for Nornet
- running a standard Linux distribution

Good geographic distribution
- voting locations all over Norway
- dense deployment in 5 cities

Connected to multiple MBB operators
- 3(4) UMTS networks
- 1 CDMA network
- LAN where available

Homogenous hardware
- Same OS/hardware
- Same modem model set



System overview

Measurement servers

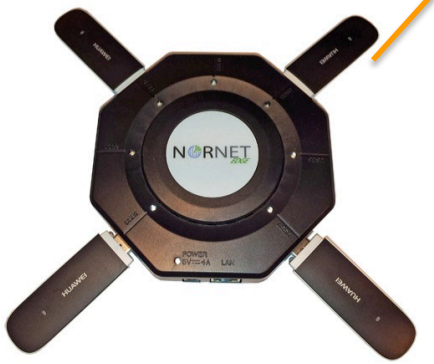
Management and data repository

Measurement traffic

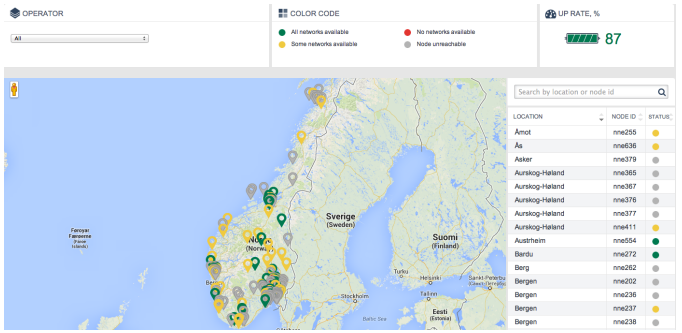
Management traffic

Measurement results

Database queries

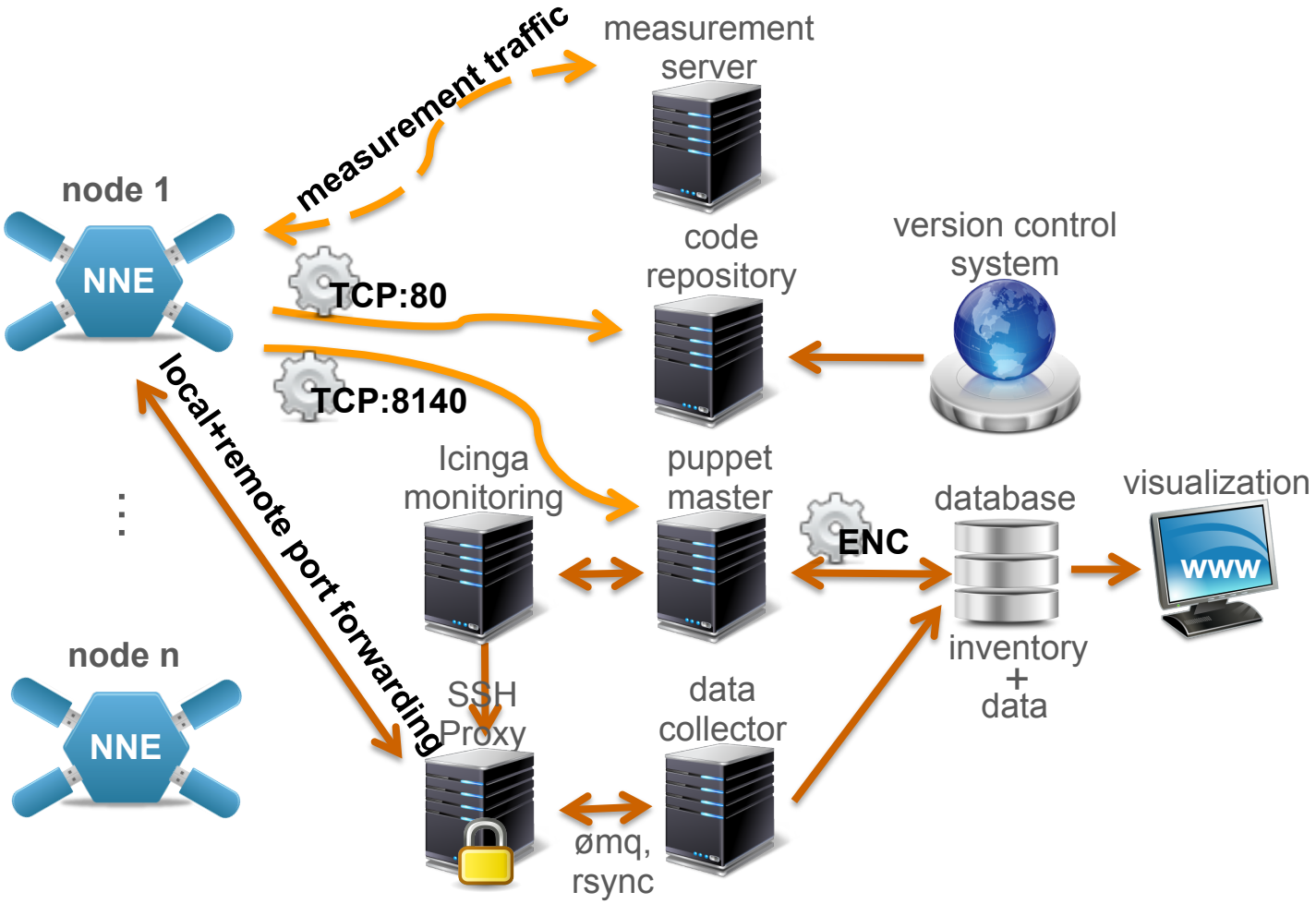


Measurement nodes



Visualization

Infrastructure



Measurement node: what's inside

- Samsung Cortex A8 1 GHz processor
- 512 MB RAM + 512 MB NAND flash
- 7 USB + 1 Ethernet ports
- 16GB SD card
- 1-4 x USB 3G (UMTS) modems:
  - Huawei E353u-2 (HSPA+)
  - Huawei E392u-12 (DC-HSPA+ and LTE)
  - Huawei E3131 (HSPA+)
  - Huawei E173u-2 (HSUPA+HSDPA)
- 1 x CDMA 1x Ev-Do modem
- 2 x USB Ethernet adapters
- 1 x USB WiFi adapter (optional)

Deployment

- More than 400 nodes were deployed since November 2012
- The majority of nodes were deployed at voting locations in collaboration with Norwegian Ministry of Local Government and Regional Development for the e-vote project
- Joint logistics efforts in bringing the nodes up and running
- The number of reachable nodes peaked at 244 during the election day (9th September 2013) and decreased to around 180 afterwards
- Some of our nodes also reside at homes of Simula employees or are paired with Nornet Core nodes (including the one in Svalbard!)

Features of the node

- Generic Linux platform with common tools available
- True multi-link environment
- Automatic network connection management and recovery
- Serves as an Internet gateway
- Watchdog for unexpected scenarios
- A /single/log/folder to save measurement results remotely
- Reachable from outside via the SSH proxy
- Contextual information available to measurement scripts:
  - RRC state (e.g. Cell_FACH or Cell_DCH)
  - Signal strength (RSSI) and signal-to-noise-ratio (CSNR: RSCP and Ec/Io)
  - Connection mode (e.g. GSM or WCDMA) and submode (e.g. HSDPA or HSPA+)
  - Network and location information
  - Other real-time metadata

Server-side components

- Automatic node configuration and management using Puppet
- Health and services monitoring using Icinga
- Two-way communication with the node over the SSH proxy
- Single relational database for inventory and measurement data
- All network connection status and context changes from the nodes are captured real-time and stored in the database
- Visualization frontend to display node statuses, real-time measurement results as well as aggregated historical data

Measurement framework

- Instances of a particular measurement can be created on a freely selected range of nodes and networks
- Long and short-running measurements are supported
- Measurements are managed entirely in the database and deployed automatically by Puppet
- Results are collected, parsed and imported into the database as they arrive (15-30 seconds delay)
- Predefined record structure for a generic measurement

Measurement framework

Measurement scripts

```
python /nne/tools/mdispatcher.py
 \_ python /nne/tools/udpping.py -i 1145 --iface eth0
 \_ python /nne/tools/udpping.py -i 3 --iface ppp0
 \_ python /nne/tools/udpping.py -i 4 --iface ppp2
 \_ python /nne/tools/udpping.py -i 5 --iface ppp3
 \_ python /nne/tools/udpping.py -i 6 --iface ppp1
```

Log directory

```
$ cat /nne/data/uping_1145.dat
2013-09-16 10:06:33.557079    1145    1    <d e="0"><rtt>0.193535</rtt></d>
2013-09-16 10:06:34.558184    1145    2    <d e="0"><rtt>0.182432</rtt></d>
2013-09-16 10:06:35.559228    1145    2    <d e="1"/>
2013-09-16 10:06:36.560419    1145    4    <d e="0"><rtt>0.210229</rtt></d>
2013-09-16 10:06:37.561457    1145    5    <d e="0"><rtt>0.199647</rtt></d>
```

lsyncd (rsync + ssh)

Example: connectivity measurement

- Measure latency of MBB and fixed networks
- 20 bytes UDP packet sent every second to the echo server
- Measure round-trip time, observe duplicates and packet loss
- Record times in microsecond precision
- Calculate loss ratio and average RTT aggregates for 5 min bins
- 733 measurement instances (on 2013-09-09)
- Around **700** records per second and **50M** per day

Challenges and lessons learned

- status(node) = Σstatus(e), where e is an attached dongle or cable, which sometimes breaks (or somebody unplugs it!)
- 3G USB modems can get stale in different ways (and we need to recover them)
- Most firewalls block DNS and NTP ports
- Puppet agent is no more stable than the default route with the lowest metric is (system clock is important too)
- NTPD always uses only one outgoing interface (“finding the numerically closest local address” – Dave Mills)
- Kernel paging or memory card errors might result in a semi-dead node, when a typical watchdog won’t help

Next steps

- Continue collaboration with municipalities to keep and maintain the existing deployment
- Introduce mobile nodes by placing them in the trains
  - Collaboration with NSB (Norwegian railways)
  - Measure both MBB and on-train WiFi network
  - Dynamic location update in the inventory
- Opening the testbed for researchers:
  - Limited access to nodes and platform components
  - Ability to run measurements on selected nodes and networks
  - API for measurements and results exposure

Thank you!

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http://nornet-testbed.no
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